X-24A, M2-F3, and HL-10 Lifting Bodies

Chapter 2

Lifting Entry With Horizontal Landing; The Quest Begins

Many concepts for accomplishing a lifting entry followed by a horizontal landing were proposed in the late 1950's. There were inflatable vehicles with very low wing loading, delta-winged flat-on-top shapes, delta-winged flat-on-bottom shapes, semi-ballistic shapes with extendable wings, and several lifting bodies. Some of these configurations received considerable attention and were tested extensively in wind tunnels. None were committed to hardware, however until about 1957 when the Air Force initiated a design competition for the X-20 "Dyna Soar" program. It was to be a continuation of the Air Forces "X-plane" research on manned, high speed flight, and was to be conducted in a fashion similar to the X-15 program. The vehicle would be designed and constructed by industry, then turned over to a joint Air Force/NACA team who would conduct the research flight testing.

An overall schedule for projects that were actually committed to hardware between 1957 and 1982 is shown in Figure 2-1. The various programs discussed in this document are related to each other, and to parallel programs by this figure.

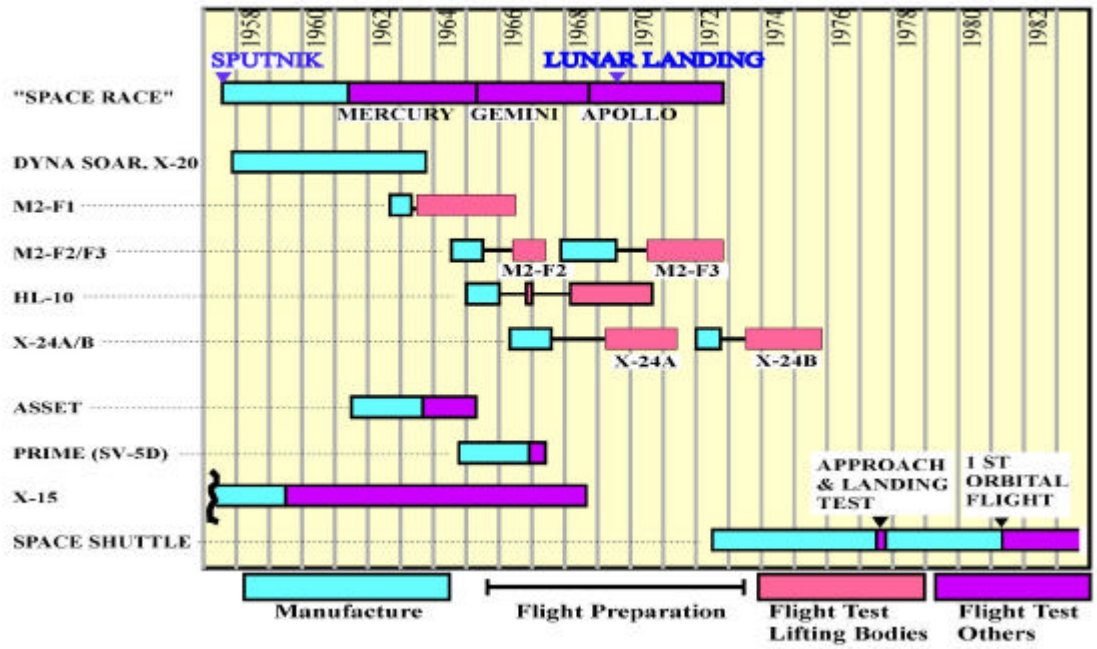

Figure 2-1: Entry-Related Testing 1957-1982

2.1 High L/D, or Low L/D?

The lifting body concept for manned entry vehicles was first introduced during the competition for the X-20 Dyna Soar contract in the mid fifties. The configuration that was finally selected for the Dyna Soar was NOT a lifting body, but was a high L/D, delta-winged glider that would use the "lifting" entry concept described in Chapter 1. The X-20 was never completed and never flew, nevertheless, it represents the first serious attempt to design and build a vehicle which would perform a lifting entry from orbit followed by a horizontal landing. The program was cancelled in December, 1963 while the first flight vehicle was under construction. A more complete description of the X-20 program is included in Appendix A.

2.2 From X-15 to X-20

The Dyna Soar program grew out of concepts first proposed by Eugen Sänger, a German scientist, in the 1930's (Reference Geiger as quoted in Hallion, Vol. I, 1987). Sänger envisioned a winged aircraft boosted to near-orbital speeds above the earth's atmosphere by a rocket engine. It would then skip along the outer reaches of the atmosphere like a flat stone on water until it slowed to a normal glide speed for landing. The term "boost-glide vehicle" was born. The range of the aircraft would be greatly extended by the skipping action, as would the maneuverability. Sänger coined the term "dynamic soaring" to describe the concept. This terminology was shortened to "Dyna Soar" as the name for the program even though the reentry was envisioned as a long, controlled glide without "skipping."

The Dyna Soar program evolved from the aircraft community rather than the missile community, which was the primary source of entry technology for the Mercury program. The Dyna Soar glider was seen as a natural progression of the successful X-series high speed rocket-powered aircraft. At the time of the first design competition in the mid fifties the X-15 was under construction. The X-15 was expected to advance the frontiers of manned flight to Mach 6.6 and to 250,000 feet altitude. It was recognized that the next step upward in speed and altitude beyond the X-15 could probably not be achieved by air-launching or by using a self-contained propulsion system. Some large, unique air-launching platforms were studied and proposed but none were built. Existing ICBM's had the capability to boost small payloads (approximately 5,000 lbs.) to orbit, but could also boost a 9,000-pound research aircraft to a speed of about 17,000 ft per second (about Mach 20) and well into the reentry heating regime. Considering the anticipated future increase in booster capability, the Dyna Soar was proposed as a research glider that would be designed for entry from orbit, but would be initially tested and developed in sub-orbital flight. The program married the ICBM booster technology and high speed research airplane technology. For launch, the glider would be mounted on the top of a modified ICBM booster. The booster trajectory would be altered to place the glider in a nearly horizontal trajectory at burnout, as envisioned by Sänger, rather than the typical steep and high ballistic trajectory of an ICBM.

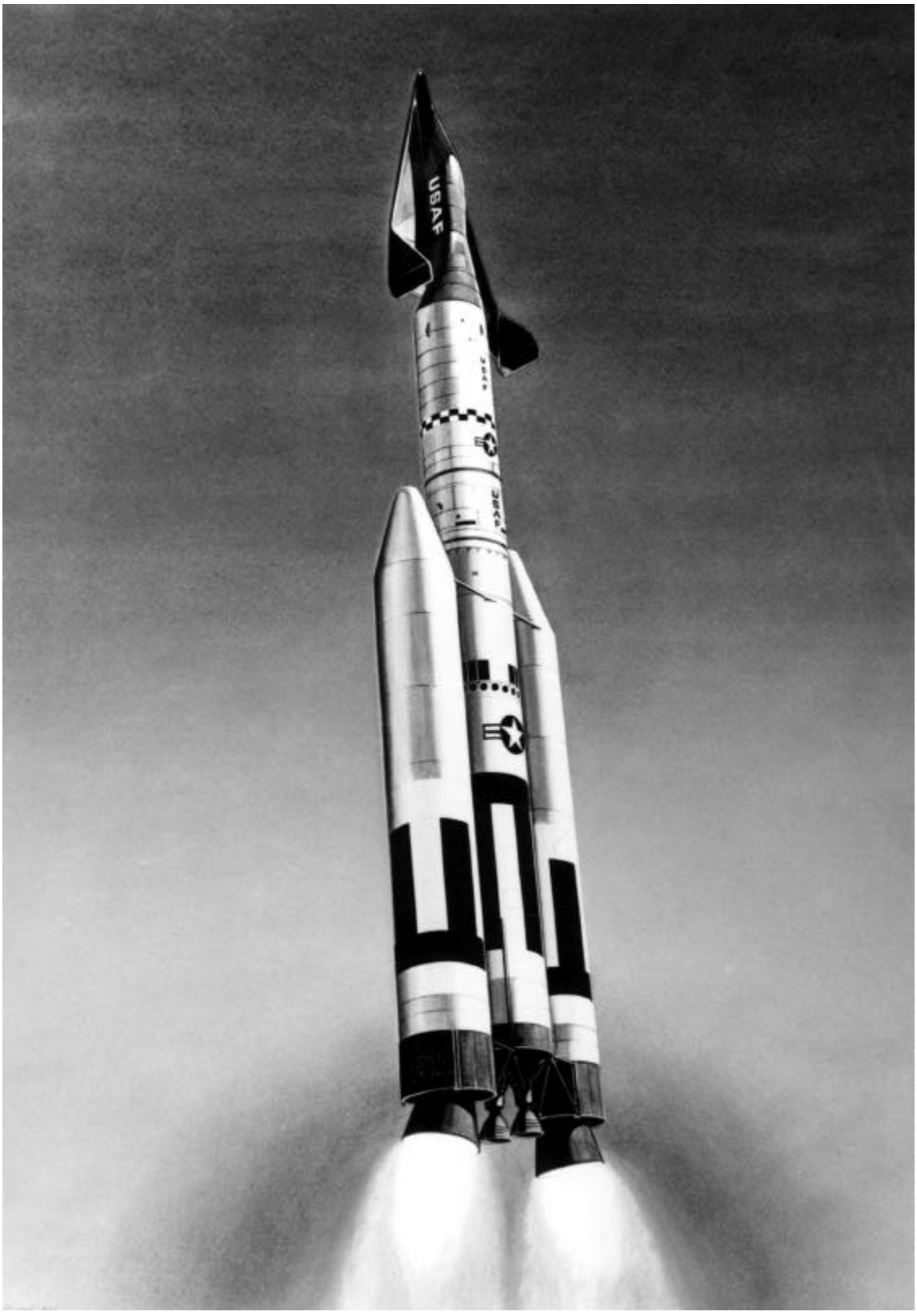

Figure 2-2: Dyna Soar Glider on Titan III Booster

2.3 Legacies of Dyna Soar

After program cancellation, several of the systems that were under development for the X-20 program found a place in the continued technology advance of the early 1960's and provided the cornerstones for the continuation of lifting entry research. Some of these systems and concepts are outlined below.

(1) The ASSET Program - The ASSET vehicle was designed to validate the "hot structure" concept of the Dyna Soar glider. The structure and shape of the vehicle represented the forward 4 feet of the X-20 in most respects. Six vehicles were built and successfully flown between 1963 and 1965 (mostly after the cancellation of the X-20) along gliding reentry trajectories . Although this program received little attention at the time, its success validated the X-20 "hot structure" thermal protection concept (Reference Hallion, Vol. I, 1987).
(2) The self-adaptive, fly-by-wire flight control system designed for the X-20 was adapted to the X-15 mission and was installed in the #3 X-15 . The features of the system, including the autopilot and the merging of aerodynamic and reaction controls, were demonstrated on many successful X-15 flights.

(3) The first Pulse Code Modulation (PCM) airborne instrumentation system was initiated for the X-20 program. The NASA FRC at Edwards recognized the potential value of this system and continued support of its development (known as the CT-77 Instrumentation System). It was used successfully on all of the lifting body programs.

(4) The Inertial Guidance System that was developed for the X-20 program also found its way into the X-15 program, where it provided a major improvement in accuracy for the later high-altitude flights.

(5) Special simulation computer hardware and software (hybrid digital/analog) were procured to provide an accurate, real-time simulation of the X-20 lifting entry for mission planning and crew training. An accurate lifting entry simulation was established at Edwards AFB, and the new equipment was used to support the lifting body programs at Edwards as well as the Space Shuttle program.

(6) The X-20 laid much of the ground work for the crew escape philosophy which is used in the Space Shuttle today. The X-20 glider design team recognized that it was not practical to provide an escape mode for all aspects of a space flight. In case of an emergency, the entry vehicle itself was considered the primary method for returning the crew to subsonic speeds. Design safety features, usually in the form of system redundancy, were incorporated in the entry vehicle to insure that it could function following most high-probability space emergencies.

(7) The booster man-rating concept was first addressed during the X-20 program. Available ICBM boosters were designed to deliver an unmanned payload one time, consequently they lacked any redundancy for emergencies. The escape towers and escape rockets used on the early manned flights of these boosters were designed to fly the manned vehicle away from the booster in the event of a fire or explosion. Although the X-20 also planned to use an abort rocket, the program highlighted the need to merge the airplane and booster man-rating philosophies for any reusable manned entry vehicle.

2.4 Death of the Dyna Soar

By December of 1963, when the Dyna Soar program was cancelled, many of the perceived barriers to lifting entry and horizontal landing had been laid to rest by the perseverance of the X-20 team. Lifting entry and horizontal landing were still viewed as the most cost-effective way to return astronauts from orbit. The stage was set for a different approach; one with less technical risk than the X-20.